MARIA-G, UNNE-1, HADES-R, HADES-ICM
DESCRIPTION OF TRANSMISSIONS

This document describes the transmissions of the MARIA-G, UNNE-1, HADES-R and HADES-ICM satellites. The first two will be launched from the United Kingdom, using the RFA One launcher. HADES-R will be launched on SpaceX's Transporter-12 mission from the United States. HADES-ICM is scheduled to be launched on the Transporter-13 mission, also from the United States.

MARIA-G and UNNE-1 are part of the joint ERMINAZ mission, together with AMSAT-DL and Libre Space Foundation.

MARIA-G incorporates software developed by high school students from the I.E.S María Guerrero high school in Collado Villalba (Madrid) in Spain. UNNE-1 incorporates a software payload developed by Nebrija University in Madrid, as well, while HADES-R and HADES-ICM incorporate a hardware payload developed by SMART-IR in Manchester (United Kingdom).

Modulations used:

All four satellites use FSK modulation with 1125 Hz tone spacing and an initial bit rate of 200 bits per second for their telemetry and regenerative digital repeater transmissions. This rate can be increased by remote command to 2400 bps. The lowest frequency (mark) represents the value of bit 1, while the highest (space) represents the value of bit 0.

Other modulations used are: FM for the voice repeater, as well as for the beacon with pre-recorded voice and CW.

Transmissions types:

There are 16 types of transmissions made from the satellite:

- Packet type 01: SAT-EARTH FSK Power telemetry
- Packet type 02: SAT-EARTH FSK Temp telemetry
- Packet type 03: SAT-EARTH FSK Status telemetry
- Packet type 04: SAT-EARTH FSK Power stats telemetry
- Packet type 05: SAT-EARTH FSK Temp stats telemetry
- Packet type 06: SAT-EARTH FSK Sunvector telemetry (light sensor data)
- Packet type 07: SAT-EARTH FSK ICM game telemetry messages (HADES-ICM)
- Packet type 08: SAT-EARTH FSK Deploy telemetry (antenna deployment data)
- Packet type 09: SAT-EARTH FSK Extended Power stats telemetry
- Packet type 10: SAT-TIERRA FSK Telemetry Nebrija University Game (UNNE-1)
- Packet type 11: SAT-TIERRA FSK Telemetry Fraunhofer experiment information (MARIA-G)
- Packet type 12: SAT-TIERRA FSK Telemetry Ephemerides
- Packet type 13: Not used
- Packet type 14: SAT-TIERRA FSK Telemetry Time series
- Packet type 15: SAT-TIERRA FSK Telemetry SMART-IR experiment data (HADES-R and HADES-ICM)
- SAT-EARTH CW transmissions (messages from the I.E.S María Guerrero games) (MARIA-G)

FSK packets (all initially at 200 bps) are distinguished from each other by the type field.

Apart from these satellite-generated transmissions, three types of retransmissions are available as a service for ground station users:

- FM voice retransmissions (Mode 1)
- FSK/AFSK data retransmissions up to 2400 bps (AX.25, APRS…) (Included in Mode 1 as well)
- FSK regenerated data retransmissions at 50-2400 bits per second (Mode 2)

Frequencies and modes

Frequencies used are as follows:

MARIA-G:
- ✓ 145.875 MHz, uplink, modes: FM voice (no subtone) and FSK 200 bps, AFSK, AX.25, APRS 1200 / 2400 bps
- ✓ 436.666 MHz downlink, modes: FM voice, CW, FSK 200 bps-2400 bps
- ✓ 436.235 MHz downlink, modes: ETSI-TS-103-357 (Fraunhofer-Gesellschaft transmitter)

UNNE-1:
- ✓ 145.925 MHz, uplink, modes: FM voice (no subtone) and FSK 200 bps, AFSK, AX.25, APRS 1200 / 2400 bps
- ✓ 436.888 MHz downlink, modes: voice FM, CW, FSK 200bps-2400bps

HADES-R:
- ✓ 145.925 MHz, uplink, modes: FM voice (no subtone) and FSK 200 bps, AFSK, AX.25, APRS 1200 / 2400 bps
- ✓ 436.888 MHz downlink, modes: FM voice, CW, FSK 200 bps-2400 bps

HADES-ICM:
- ✓ 145.875 MHz, uplink, modes: FM voice (no subtone) and FSK 200 bps, AFSK, AX.25, APRS 1200 / 2400 bps
- ✓ 436.666 MHz downlink, modes: FM voice, CW, FSK 200 bps-2400 bps

If the satellite is working in FM voice/FSK data repeater mode (mode 1), it is activated by level without the need for subtone.

In the specific case of the FSK regenerative packet repeater (Transponder in mode 2), when this is active, the received signals are sampled, digitally restored and sent to the transmission module.

After launch, by default, the satellites are in mode 0 (transponder deactivated), being necessary to activate them by remote command.

The satellites also have a limited Store & Forward capacity (byte by byte), implemented conceptually and managed only by remote commands.

Transmissions format

The format of each transmission is as follows:

CW

The CW beacon is transmitted in the format:

VVV XXXXXX or VVV SXX.XX SXX.XX for MARIA-G (Science question code or Geographic coordinate)

CW, as well as other transmissions, may not be generated if the satellite is in a low power state.

FSK packets

FSK packets generated at the satellite can be of the types indicated above.

Each of them is generated at the time of its transmission and its bytes are sent in a ‘MSB first’ (most significant bit first) format.

Scrambling of data packets

A scrambling process is carried out on all FSK packets. The only fields that are not encoded are the training sequence itself, the synchronization field, the packet type (fields 1, 2 and 3 in all packets) and the CRC, which is placed at the end.

The encoding and decoding algorithms are based on a multiplicative scrambler. The implementation of the scrambler is defined by the following polynomial: G(x)=x^17+x^12+1. Figures 1 and 2 show the multiplicative encoder and decoder respectively.

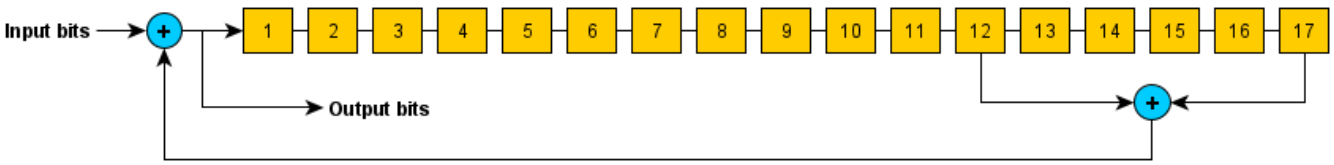

Figure 1. Implementation of the shift register for the multiplicative encoder.

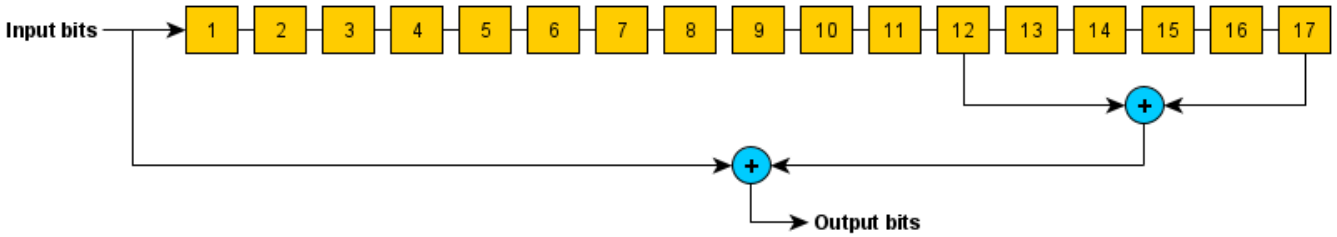

Figure 2. Implementation of the shift register for the multiplicative decoder.

Although it is not very common and because not all packet fields are encoded, we initialize the shift registers for each received packet. The initial state of the registers (assuming we use a 32-bit variable for the implementation) is 0x2C350000 and we only apply the shift register to the encoded bits.

Example:

Data input (ASCII): “GENESIS-Genesis”.
Data encoded (Hex): 0xC7434C274B1713 D76B05AAD189 9747C8.
Data decoded (ASCII): “GENESIS-Genesis”.

CRC calculation

The CRC checksum calculation is done using CRC-CCITT-FALSE. Figure 3 shows the shift register used for the CRC calculation algorithm. The CRC is applied starting from the type field to the end of the data in each packet.

Polynomial: 0x1021.
Initial value: 0xFFFF.
Final xor value: 0x0.

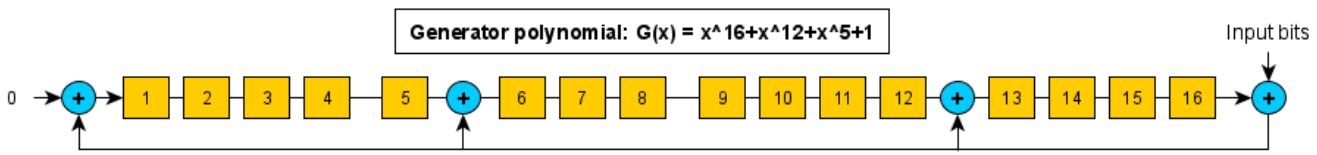

Figure 3. 16-bit CRC-CCITT-FALSE shift register.

Example:

- Input string: “EASAT-2”.
- **CRC output**: 0x7D58.

NOTE: Source code for CRC and scrambler is available in the website

Description of FSK packets

The structure of each packet is described below. They all begin with a 64-bit training sequence of alternating ones and zeros, followed by two synchronization bytes, which allow the receiver to detect the beginning of the packet. The next field will always be the type, which allows distinguishing one from another, and the source address, which in this case will be 2 if the satellite is HADES-ICM, B if the satellite is MARIA-G, C if it is UNNE-1 or D if it is HADES-R.

The fields are always sent in MSB format first, that is, the most significant bit is the first to be sent (the one on the far left).

FSK packet type 01: Power

Packet type 01 provides data on the power generated, as well as the most representative voltages and currents of the satellite. It is sent even if the satellite has little power.

ID	Bits	FIELD NAME	MU	DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 1
4	4	Address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	Sclock	s	System clock at transmission time
6	8	Spa	mW	SPA (Panel A power) I2C Max power (last 3 minutes)
7	8	Spb	mW	SPB (Panel B power) I2C Max power (last 3 minutes)
8	8	Spc	mW	SPC (Panel C power) I2C Max power (last 3 minutes)
9	8	Spd	mW	SPD (Panel D power) I2C Max power (last 3 minutes)
10	16	Spi	mW	SPI Total instant power (SPA+SPB+SPC+SPD)
11	12	vbus1	mV	VBUS1 CPU.ADC MPPT Output
12	12	vbat1	mV	VBAT1 EPS.ADC BAT
13	12	Vcpu	mV	VCPU CPU.ADC
14	16	vbus2	mV	VBUS2 EPS.I2C (VBUS at EPS)
15	12	vbus3	mV	VBUS3 CPU.I2C (VBUS at CPU) I2C
16	12	vbat2	mV	VBAT2 EPS.I2C (Payload voltage) EPS.I2C
17	12	Ibat	mA	IBAT I2C (Battery current) I2C
18	12	Icpu	mA	ICPU I2C (CPU current) I2C
19	12	Ipl	mA	IPL (Payload current) I2C, EPS board
20	8	Peaksignal	dBm	Peak signal in last POWER transmission, 1 LSB=0.5dB
21	8	Modasignal	dBm	Noise level in last POWER transmission, 1 LSB=0.5dB
22	8	Lastcmdsignal	dB	Signal level of last command received E2P, 1 LSB=0.5dB
23	8	Lastcmdnoise	dB	Noise level of last command received E2P, 1 LSB=0.5dB
24	16	Checksum	--	Checksum
useful	248	Bits		
	31,00	Bytes		
total	392	Bits		NOTE: Scrambling is applied after address to the last field without including checksum
total	49	Bytes		The checksum does include type/address until the end
time	1960	Ms		

FSK packet type 02: Temperature

Package type 02 contains the different temperatures measured in the system. This package is sent even in low energy states.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 2
4	4	Address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	Sclock	s	System clock at transmission time
6	8	Tpa	oC	TPA (Panel A Temperature) I2C
7	8	Tpb	oC	TPB (Panel B Temperature) I2C
8	8	Tpc	oC	TPC (Panel C Temperature) I2C
9	8	Tpd	oC	TPD (Panel D Temperature) I2C
10	8	Tpe	oC	TPE (Panel E Temperature) I2C - Not used
11	8	Teps	oC	TEPS (EPS Temperature) I2C
12	8	Ttx	oC	TTX (TX Temperature) I2C
13	8	ttx2	oC	TTX2 (TX Temperature) NTC
14	8	Trx	oC	TRX (RX Temperature) NTC
15	8	Tcpu	oC	TCPU (CPU Temperature) ADC
16	16	checksum	--	Checksum
useful	136	Bits		
	17,00	Bytes		0.5 degrees resolution 0 = <=-40C and 254 = >=87C 255 = ERROR
total	280	Bits		
total	35	Bytes		
time	1400	Ms		

FSK packet type 03: Status

Packet type 03 contains satellite status information. It is always sent even in low power states.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	**Training**	--	0xAAAAAAAA
2	16	**Sync**	--	0xBF35
3	4	**Type**	--	Packet type: 3
4	4	**Address**	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	Sclock	s	Local time at satellite
6	32	Uptime	s	Uptime in seconds
7	16	Nrun	--	CPU runs
8	8	Npayload	--	Payload activation counter (including failed)
9	8	Nwire	--	Antenna deploy attemps
10	8	ntransponder	--	Transponder activation counter
11	4	npayloadFails	--	Payload fails
12	4	Lstrst	--	Last reset reason

13	4	Bate	--	Battery status 0-F
14	4	Mote	--	Transponder mode: - Mode 0 (Off) - Mode 1 FM->FM - Mode 2 FSK->FSK regenerative
15	8	nTasksNotExecuted	--	Tasks lost by scheduler
16	8	antennaDeployed	--	Antenna deployed: 0 not deployed, 1 deployed, 2 unknown status
17	8	nExtEepromErrors	--	Checksum failures in EEPROM since last check (recoverable)
18	8	failedTaskID	HEX	Id of the last task failed to execute
19	8	mensajeria_habilitada		Messagine enabled
20	8	strfwd0 / last id	HEX	S&F id
21	16	strfwd1 / last cmd	HEX	S&F cmd
22	16	strfwd2 / last value	HEX	S&F value
23	8	strfwd3	HEX	Number of successfully commands executed
24	16	**checksum**	--	Checksum
useful	**232**	Bits		
	29,00	Bytes		
total	**376**	Bits		
total	**47**	Bytes		
time	**1880**	Ms		

FSK packet type 04: Power stats

Packet type 04 contains power statistics collected since the last satellite reset.

ID	bits	FIELD NAME	MU	DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet ype: 4
4	4	Address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	Sclock	s	System clock at transmission time
6	12	minvbus1	mV	MIN VBUS1 CPU.ADC MPPT
7	12	minvbat1	mV	MIN VBAT1 EPS.ADC BAT
8	12	minvcpu	mV	MIN VCPU CPU.ADC
9	4	Free	--	
10	8	minvbus2	mV	MIN VBUS2 EPS.I2C
11	8	minvbus3	mV	MIN VBUS3 CPU.I2C
12	8	minvbat2	mV	MIN VBAT2 EPS.I2C
13	8	Minibat	mV	MIN IBAT I2C
14	8	Minicpu	mV	MIN ICPU I2C
15	8	Minipl	mV	MIN IPL
16	12	maxvbus1	mV	MAX VBUS1 CPU.ADC
17	12	maxvbat1	mV	MAX VBAT1 EPS.

18	12	maxvcpu	mV	MAX VCPU CPU.ADC
19	4	Free	--	
20	8	maxvbus2	mV	MAX VBUS2 EPS.I2C
21	8	maxvbus3	mV	MAX VBUS3 CPU.I2C
22	8	maxvbat2	mV	MAX VBAT2 EPS.I2C
23	8	Maxibat	mV	MAX IBAT I2C
24	8	Maxicpu	mV	MAX ICPU I2C
25	8	Maxipl	mV	MAX IPL
26	8	ibat_rx_charging	mA	last measured ibat when rx and charging
27	8	ibat_rx_discharging	mA	last measured ibat when rx and discharging
28	8	ibat_tx_low_power_charging	mA	last measured ibat when tx in low power and charging
29	8	ibat_tx_low_power_discharging	mA	last measured ibat when tx in low power and discharging
30	8	ibat_tx_high_power_charging	mA	last measured ibat when tx in high power and charging
31	8	ibat_tx_high_power_discharging	mA	last measured ibat when tx in high power and discharging
32	16	checksum	--	checksum
useful	280	Bits		
	35,00	Bytes		
total	424	Bits		
total	53	Bytes		
Time	2120	Ms		

FSK packet type 05: Temp stats

Packet type 5 contains temperature statistics since the last satellite reset.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 5
4	4	Address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	Sclock	s	System clock at transmission time
6	8	Mintpa	oC	MIN TPA (Panel A Temperature) I2C
7	8	Mintpb	oC	MIN TPB (Panel B Temperature) I2C
8	8	Mintpc	oC	MIN TPC (Panel C Temperature) I2C
9	8	Mintpd	oC	MIN TPD (Panel D Temperature) I2C
10	8	Mintpe	oC	MIN TPE (Panel E Temperature) I2C - Not used
11	8	Minteps	oC	MIN TEPS (EPS Temperature) I2C
12	8	Minttx	oC	MIN TTX (TX Temperature) I2C
13	8	minttx2	oC	MIN TTX2 (TX Temperature) NTC
14	8	Mintrx	oC	MIN TRX (RX Temperature) NTC
15	8	Mintcpu	oC	MIN TCPU (CPU Temperature) ADC
16	8	Maxtpa	oC	MAX TPA (Panel A Temperature) I2C
17	8	Maxtpb	oC	MAX TPB (Panel B Temperature) I2C

18	8	Maxtpc	oC	MAX TPC (Panel C Temperature) I2C
19	8	Maxtpd	oC	MAX TPD (Panel D Temperature) I2C
20	8	Maxtpe	oC	MAX TPE (Panel E Temperature) I2C - Not used
21	8	Maxteps	oC	MAX TEPS (EPS Temperature) I2C
22	8	Maxttx	oC	MAX TTX (TX Temperature) I2C
23	8	maxttx2	oC	MAX TTX2 (TX Temperature) NTC
24	8	Maxtrx	oC	MAX TRX (RX Temperature) NTC
25	8	Maxtcpu	oC	MAX TCPU (CPU Temperature) ADC
26	16	checksum	--	checksum
useful	216	Bits		
	27,00	Bytes		
total	360	Bits		
total	45	Bytes		
time	1800	Ms		

FSK packet type 06: Sunsensors

Package type 6 contains samples of the light sensors. This is an initial experiment for use in future orientation control.

ID	bits	VARIABLE		DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 6
4	4	Address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	96	td[6]	s	Seconds between samples (values 1,2,4,8,16,32,64,128)
6	768	v - valores luz[8][6]		Detection tables (SPA, SPB, SPC, SPD, 90A, 90D), v - light[8][6] - 16 bits
7	128	p - valores pico[8] - 16 bits		Peak values (SPA, SPB, SPC, SPD, 90A, 90D), p - [8] -16 bits
8	64	err sensor en error[8]		Sensor status (ok or error)[8] (1 error, 0 ok) - 8 bits
9	16	checksum	--	checksum
useful	1080	Bits		
	135,00	Bytes		
total	1224	Bits		
total	153	Bytes		
time	6120	Ms		

FSK Packet type 07: ICM game messages

Packet type 7 contains string messages of the ICM game. Those messages are a small story it can be collected.

ID	bits	VARIABLE		DESCRIPTION
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 7
4	4	Address	--	Source address: 2 for HADES-ICM

5	32	Sclock	s	System clock at transmission time
6	8	message_number	--	message_number[0..9]
7	744	data	--	char 0 - char 92 (messages are 98 chars fixed length)
8	16	checksum	--	checksum
Useful	808	bits		
	101,0	bytes		
Total	952	bits		
	119,0	bytes		
time	4760	ms		

FSK Packet type 08: Deploy

Packet type 8 contains information about the system parameters during the last antenna deployment.

ID	Bits	VARIABLE		DESCRIPTION
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 8
4	4	address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	16	v1oc		v1oc;
6	16	v1		v1
7	16	i1		i1
8	16	i1pk		i1pk
9	16	r1		r1
10	16	v2oc		v2oc;
11	16	v2		v2
12	16	r2		r2
13	32	t0		t0
14	16	td		Td
15	8	state_begin:1;		state_begin:1;
16	8	state_end:1;		state_end:1;
17	8	state_now:1;		state_now:1;
18	8	enable:1;		enable:1;
19	8	counter		counter;
20	8	tmp		tmp;
21	16	checksum		checksum
useful	248	bits		
	31,00	bytes		
total	392	bits		
total	49	bytes		
time	1960	ms		

FSK packet type 09: Extended power stats (INA)

Packet type 9 contains extended information about power statistics in the system.

ID	bits	FIELD NAME	MU	DESCRIPTION
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 9
4	4	address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	16	v0	raw	SPA V Instant voltage
6	16	i0	raw	SPA I Instant current
7	16	p0	raw	SPA P Mean power
8	16	vp0	raw	SPA VP Peak voltage
9	16	ip0	raw	SPA IP Peak current
10	16	pp0	raw	SPA PP Peak power
11	16	v1	raw	SPB V Instant voltage
12	16	i1	raw	SPB I Instant current
13	16	p1	raw	SPB P Mean power
14	16	vp1	raw	SPB VP Peak voltage
15	16	ip1	raw	SPB IP Intensidad pico
16	16	pp1	raw	SPB PP Potencia pico
17	16	v2	raw	SPC V Instant voltage
18	16	i2	raw	SPC I Instant current
19	16	p2	raw	SPC P Mean power
20	16	vp2	raw	SPC VP Peak voltage
21	16	ip2	raw	SPC IP Intensidad pico
22	16	pp2	raw	SPC PP Potencia pico
23	16	v3	raw	SPD V Instant voltage
24	16	i3	raw	SPD I Instant current
25	16	p3	raw	SPD P Mean power
26	16	vp3	raw	SPD VP Peak voltage
27	16	ip	raw	SPD IP Intensidad pico
28	16	pp3	raw	SPD PP Potencia pico
29	16	v4	raw	SUN V Instant voltage
30	16	i4	raw	SUN I Instant current
31	16	p4	raw	SUN P Mean power
32	16	vp4	raw	SUN VP Peak voltage
33	16	ip4	raw	SUN IP Intensidad pico
34	16	pp4	raw	SUN PP Potencia pico
35	16	v5	raw	BAT V Instant voltage
36	16	i5	raw	BAT I Instant current
37	16	p5	raw	BAT P Mean power
38	16	vp5	raw	BAT VP Peak voltage
39	16	ip5	raw	BAT IP Intensidad pico
40	16	pp5	raw	BAT PP Potencia pico
41	16	v6	raw	BATP V Instant voltage
42	16	i6	raw	BATP I Instant current
43	16	p6	raw	BATP P Mean power

44	16	vp6	raw	BATP VP Peak voltage
45	16	ip6	raw	BATP IP Intensidad pico
46	16	pp6	raw	BATP PP Potencia pico
47	16	v7	raw	BATN V Instant voltage
48	16	i7	raw	BATN I Instant current
49	16	p7	raw	BATN P Mean power
50	16	vp7	raw	BATN VP Peak voltage
51	16	ip7	raw	BATN IP Intensidad pico
52	16	pp7	raw	BATN PP Potencia pico
53	16	v8	raw	CPU V Instant voltage
54	16	i8	raw	CPU I Instant current
55	16	p8	raw	CPU P Mean power
56	16	vp8	raw	CPU VP Peak voltage
57	16	ip8	raw	CPU IP Intensidad pico
58	16	pp8	raw	CPU PP Potencia pico
59	16	v9	raw	PL V Instant voltage
60	16	i9	raw	PL I Instant current
61	16	p9	raw	PL P Mean power
62	16	vp9	raw	PL VP Peak voltage
63	16	ip9	raw	PL IP Intensidad pico
64	16	pp9	raw	PL PP Potencia pico
65	16	checksum	--	checksum
useful	984	bits		
	123,00	bytes		
total	1128	bits		
total	141	bytes		
time	5640	ms		

FSK packet type 10: Nebrija University Game

This type 10 packet contains information about the game implemented by Nebrija University. It is only broadcast on the UNNE-1 satellite.

ID	**bits**	**FIELD NAME**		**DESCRIPTION**
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 10 – (Only UNNE-1 satellite)
4	4	address	--	Source address: C for UNNE-1
5	32	clock_tx	--	System clock at transmission time
6	8	week_number		Week since deployment of the satellite
7	8	stored_status		Internal payload status
8	8	data0	--	data0
9	8	data1	--	data1
10	8	data2	--	data2
11	8	data3	--	data3
12	8	data4	--	data4

13	8	data5	--	data5
14	8	data6	--	data6
15	8	data7	--	data7
16	16	checksum	--	checksum
useful	136	bits		
	17,0	bytes		
total	280	bits		
total	35	bytes		
time	1400	ms		

FSK packet type 11: Fraunhofer experiment information

This packet sends temperatures measured at the Fraunhofer transmitter. It is only transmitted on the MARIA-G satellite.

ID	bits	FIELD NAME		DESCRIPTION
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 11 – (Only MARIA-G satellite)
4	4	address	--	Source address: B for MARIA-G
5	32	clock_tx	--	System clock at transmission time
	8	data0		data0
15	8	data1	--	data1
23	16	checksum	--	checksum
useful	72	bits		
	9,0	bytes		
total	216	bits		
total	27	bytes		
time	1080	ms		

FSK packet type 12: Ephemeris

This package contains the satellite's ephemerides. These basically consist of the TLE that is sent as a command from the Earth station, as well as the calculations of its latitude, longitude and altitude that are performed on board the satellite.

ID	bits	FIELD NAME		DESCRIPTION
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 12
4	4	address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	UTC	--	Time UTC
6	16	adr		Sattellite
7	32	ful		Not used
8	32	fdl		Not used
9	32	tle.epoch		TLE element
10	32	tle.xndt2o		TLE element
11	32	tle.xndd6o		TLE element
12	32	tle.bstar		TLE element

13	32	tle.xincl		TLE element
14	32	tle.xnodeo		TLE element
15	32	tle.eo		TLE element
16	32	tle.omegao		TLE element
17	32	tle.xmo		TLE element
18	32	tle.xno		TLE element
19	16	lat		Calculated latitude
20	16	lon		Calculated longitude
21	16	alt	--	Calculated heigh
22	8	cnt		Not used
23	16	checksum	--	checksum
useful	512	bits		
	64,0	bytes		
total	656	bits		
total	82	bytes		
time	3280	ms		

FSK packet type 13: Not used

This packet is not used in these satellites.

FSK packet type 14: Time series

The time series package displays data for several variables over the last 90 minutes. Its structure is as follows:

ID	**bits**	**FIELD NAME**		**DESCRIPTION**
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type: 14
4	4	address	--	Source address: 2 HADES-ICM, B MARIA-G, C UNNE-1, D HADES-R
5	32	sclock	s	System clock for sample 0
6	8	variable	--	00=peak signal, 01=moda noise, 02=vbat1, 03=tcpu, 04=tpa, 05=(tpa+tpb+tpc+tpd)/4
7	8	byte_00	--	byte_00 oldest, it is lost each 60 minutes. Each byte hold a sample taken each 3 minutes.
8	8	byte_01	--	byte_01
9	8	byte_02	--	byte_02
10	8	byte_03	--	byte_03
11	8	byte_04	--	byte_04
12	8	byte_05	--	byte_05
13	8	byte_06	--	byte_06
14	8	byte_07	--	byte_07
15	8	byte_08	--	byte_08
16	8	byte_09	--	byte_09
17	8	byte_10	--	byte_10
18	8	byte_11	--	byte_11
19	8	byte_12	--	byte_12

20	8	byte_13	--	byte_13
21	8	byte_14	--	byte_14
22	8	byte_15	--	byte_15
23	8	byte_16	--	byte_16
24	8	byte_17	--	byte_17
25	8	byte_18	--	byte_18
26	8	byte_19	--	byte_19
27	8	byte_20	--	byte_20
28	8	byte_21	--	byte_21
29	8	byte_22	--	byte_22
30	8	byte_23	--	byte_23
31	8	byte_24	--	byte_24
32	8	byte_25	--	byte_25
33	8	byte_26	--	byte_26
34	8	byte_27	--	byte_27
35	8	byte_28	--	byte_28
36	8	byte_29	--	byte_29 newest
37	16	checksum	--	checksum
useful	304	bits		
	38,0	bytes		
total	448	bits		
	56,0	bytes		
time	2240	ms		

FSK packet type 15: SMART-IR experiment data

This package contains the information (temperatures) from the SMART-IR experiment. It is only transmitted on the HADES-R and HADES-ICM satellites.

ID	**bits**	**FIELD NAME**		**DESCRIPTION**
1	128	training	--	0xAAAAAAAA
2	16	sync	--	0xBF35
3	4	type	--	Packet type 15 - Only HADES-R and HADES-ICM
4	4	address	--	Source address: 2 for HADES-ICM, D for HADES-R
5	32	experiment_clock	--	System clock when experiment started
6	8	experiment_id		Experiment id
7	8	frame_number	--	Frame number
8	8	data0	--	data0
9	8	data1	--	data1
10	8	data2	--	data2
11	8	data3	--	data3
12	8	data4	--	data4
13	8	data5	--	data5
14	8	data6	--	data6
15	8	data7	--	data7
16	8	data8	--	data8

17	8	data9	--	data9
18	8	data10	--	data10
19	8	data11	--	data11
20	8	data12	--	data12
21	8	data13	--	data13
22	8	data14	--	data14
23	8	data15	--	data15
24	8	data16	--	data16
25	8	data17	--	data17
26	8	data18	--	data18
27	8	data19	--	data19
28	8	data20	--	data20
29	8	data21	--	data21
30	8	data22	--	data22
31	8	data23	--	data23
32	8	data24	--	data24
33	8	data25	--	data25
34	8	data26	--	data26
35	8	data27	--	data27
36	8	data28	--	data28
37	8	data29	--	data29
38	8	data30	--	data30
39	8	data31	--	data31
40	16	checksum	--	checksum
useful	328	bits		
	41,0	bytes		
total	472	bits		
	59,0	bytes		
time	2360	ms		

FSK, CW and transponder telemetry timing patterns

MARIA-G, UNNE-1, HADES-R and HADES-ICM have two possible operating modes, configurable by remote command: Debug mode (default), where all telemetry is transmitted, and operation mode, where preference is given to the transponder, and therefore only the ephemeris packet is transmitted every 3 minutes.

When operating in debug mode, transmissions follow a cyclical pattern shown in the left column (sequence) of the table below. Transmissions are made in 30-second slots. If when a transmission is about to begin, the slot is occupied (because a previous transmission has not finished or the transponder is active, for example), it will be attempted in the next slot, but no transmission in the sequence is skipped. Tx_payload depends on the satellite, as shown in the notes, as well as tx_conditional. Tx_time_series can contain four different types of data (one variable is transmitted at a time). If power is low, only the indicated packets are transmitted.

Sequence	Notes:		
tx_status			
tx_payload	tx_payload	MARIA-G	María Guerrero (CW)
tx_power		UNNE-1	Nebrija University game
tx_time_series		HADES-R/ICM	Smart-IR experiment
tx_temp	Asterisc: not in HADES-R/ICM		
tx_ephemeris			
tx_status	tx_conditional	Si MARÍA-G	tx_deploy
tx_power_stats			Empty
tx_payload*			Fraunhofer_telemetry data
tx_power			
tx_temp_stats		Demás:	tx_deploy
tx_temp			vacío
tx_conditional			
tx_status	If low battery	tx_status	(in their times)
tx_power		tx_power	
tx_payload*		tx_temp	
tx_time_series		tx_ephemeris	
tx_temp			
tx_ephemeris			
tx_status	tx_time_series	0	Speak signal
tx_sunvector		1	Moda noise
tx_power		2	vbat1
tx_payload*		3	Tcpu
tx_ine		4	tpa
tx_temp		5	(tpa+tpb+tpc+tpd)/4
tx_time_series			
tx_time_series			
tx_time_series			

Fraunhofer Institute Module Broadcasts

The transmissions of this module are independent and occur every 6 minutes, with a duration of 30 seconds.

Transponder operation

The transponder is switched off after launch and must be activated by remote control. Once activated, it can be used immediately after any transmission. If activated, it will remain active until the end of the minute and must be renewed breaking again the squelch level.

The transponder operates by level without the need for subtones.

More information

More information, updates and implementation of the Ground Station can be found on the AMSAT EA website, in the projects section: https://www.amsat-ea.org/proyectos/